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Stainless Steel - Grade 304

Chemical Formula

Fe, <0.8% C, 17.5-20% Cr, 8-11% Ni, <2% Mn, <1% Si, <0.045% P, <0.(
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Topics Covered

Background

Grade 304 is the standard "18/8" stainless; it is the most versatile and mos widely used stainless steel, available in a wider range of products, forms an finishes than any other. It has excellent forming and welding characteristics The balanced austenitic structure of Grade 304 enables it to be severely de drawn without intermediate annealing, which has made this grade dominan the manufacture of drawn stainless parts such as sinks, hollow-ware and saucepans. For these applications it is common to use special "304DDQ" (D Drawing Quality) variants. Grade 304 is readily brake or roll formed into a variety of components for applications in the industrial, architectural, and transportation fields. Grade 304 also has outstanding welding characteristic Post-weld annealing is not required when welding thin sections.

Grade 304L, the low carbon version of 304, does not require post-weld annealing and so is extensively used in heavy gauge components (over abo 6mm). Grade 304H with its higher carbon content finds application at eleva temperatures. The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Key Properties

These properties are specified for flat rolled product (plate, sheet and coil) i ASTM A240/A240M. Similar but not necessarily identical properties are spe for other products such as pipe and bar in their respective specifications.

Composition

Typical compositional ranges for grade 304 stainless steels are given in tabl

Table 1. Composition ranges for 304 grade stainless steel

Grade		C	Mn	Si	P	S	Cr	Mo	Ni
304	min.	-	-	-	-	-	18.0	-	8.0
	max.	0.08	2.0	0.75	0.045	0.030	20.0		10.5
304L	min.	-	-	-	-	-	18.0	-	8.0
	max.	0.030	2.0	0.75	0.045	0.030	20.0		12.0
304H	min.	0.04	-	-	-	-	18.0	-	8.0
	max.	0.10	2.0	0.75	0.045	0.030	20.0		10.5

Mechanical Properties

Typical mechanical properties for grade 304 stainless steels are given in tat

Table 2. Mechanical properties of 304 grade stainless steel

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brin (HB)
304	515	205	40	92	20
304L	485	170	40	92	20
304H	515	205	40	92	20
304H also has a requirement for a grain size of ASTM No 7 or coarser.					

Physical Properties

Typical physical properties for annealed grade 304 stainless steels are giver table 3.

Table 3. Physical properties of 304 grade stainless steel in the anneale condition

Grade	Density (kg/m^3)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion (μm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Elect Resis (nΩ
			0-100°C	0-315°C	0-538°C	at 100°C	at 500°C		
304/L/H	8000	193	17.2	17.8	18.4	16.2	21.5	500	7

Grade Specification Comparison

Approximate grade comparisons for 304 stainless steels are given in table 4

Table 4. Grade specifications for 304 grade stainless steel

Grade	UNS No	Old British		Euronorm		Swedish SS	Japa J
		BS	En	No	Name		
304	S30400	304S31	58E	1.4301	X5CrNi18-10	2332	SUS
304L	S30403	304S11	-	1.4306	X2CrNi19-11	2352	SUS
304H	S30409	304S51	-	1.4948	X6CrNi18-11	-	
These comparisons are approximate only. The list is intended as a comparison of functionally similar materials **not** as a schedule of contractual equivalents. If exact equivalents are neede original specifications must be consulted.							

Possible Alternative Grades

Possible alternative grades to grade 304 stainless steels are given in table 5

Table 5. Possible alternative grades to 304 grade stainless steel

Grade	Why it might be chosen instead of 304
301L	A higher work hardening rate grade is required for certain roll formed or stretch fori components.
302HQ	Lower work hardening rate is needed for cold forging of screws, bolts and rivets.
303	Higher machinability needed, and the lower corrosion resistance, formability and weldability are acceptable.
316	Higher resistance to pitting and crevice corrosion is required, in chloride environmei
321	Better resistance to temperatures of around 600-900°C is needed...321 has higher I strength.
3CR12	A lower cost is required, and the reduced corrosion resistance and resulting discolouration are acceptable.
430	A lower cost is required, and the reduced corrosion resistance and fabrication characteristics are acceptable.

Corrosion Resistance

Excellent in a wide range of atmospheric environments and many corrosive media. Subject to pitting and crevice corrosion in warm chloride environmei and to stress corrosion cracking above about 60°C. Considered resistant to potable water with up to about 200mg/L chlorides at ambient temperatures reducing to about 150mg/L at 60°C.

Heat Resistance

Good oxidation resistance in intermittent service to 870°C and in continuou service to 925°C. Continuous use of 304 in the 425-860°C range is not recommended if subsequent aqueous corrosion resistance is important. Gra 304L is more resistant to carbide precipitation and can be heated into the a temperature range.

Grade 304H has higher strength at elevated temperatures so is often used 1 structural and pressure-containing applications at temperatures above abou 500°C and up to about 800°C. 304H will become sensitised in the temperat range of 425-860°C; this is not a problem for high temperature applications will result in reduced aqueous corrosion resistance.

Heat Treatment

Solution Treatment (Annealing) - Heat to 1010-1120°C and cool rapidly. Th grades cannot be hardened by thermal treatment.

Welding

Excellent weldability by all standard fusion methods, both with and without metals. AS 1554.6 pre-qualifies welding of 304 with Grade 308 and 304L wi 308L rods or electrodes (and with their high silicon equivalents). Heavy wel sections in Grade 304 may require post-weld annealing for maximum corros resistance. This is not required for Grade 304L. Grade 321 may also be use an alternative to 304 if heavy section welding is required and post-weld hea treatment is not possible.

Machining

A "Ugima" improved machinability version of grade 304 is available in bar products. "Ugima" machines significantly better than standard 304 or 304L, giving higher machining rates and lower tool wear in many operations.

Dual Certification

It is common for 304 and 304L to be stocked in "Dual Certified" form, particularly in plate and pipe. These items have chemical and mechanical

properties complying with both 304 and 304L specifications. Such dual certi product does not meet 304H specifications and may be unacceptable for hiç temperature applications.

Applications

Typical applications include:

- Food processing equipment, particularly in beer brewing, milk processin wine making.
- Kitchen benches, sinks, troughs, equipment and appliances
- Architectural panelling, railings & trim
- Chemical containers, including for transport
- Heat Exchangers
- Woven or welded screens for mining, quarrying & water filtration
- Threaded fasteners
- Springs

Source: Atlas Steels Australia

For more information on this source please visit Atlas Steels Australia

The information below is intended to provide introductory material for elementary students and further material for high school students.

Please keep in mind that not all demonstrations are presented at each show, and each topic may not be covered.

Complete List of Topics Covered

THERMAL CONDUCTIVITY

Introduction:

- **Heat moves through a material at a specific rate. The rate it travels depends on the material itself: some materials allow heat to move quickly through them, some materials allow heat to move very slowly through them.**

When heat is applied to a portion of a material, that heat will move through the material. Depending on the composition of the atoms of that material, the heat may move very slowly, or it may move very quickly. Heat moves very quickly through a metal spoon, for instance: leaving one end of a spoon in boiling water will make the entire spoon hot very quickly. The entire spoon becomes hot, not just the spot in the boiling water. On the other hand, heat moves very slowly through the insulation in your house. When it is very cold outside, the heat from your house moves slowly from one side of the insulation to the other. This helps keep the heating costs of your house down.

- **When two objects of different temperatures are put in contact with one another, there is an exchange of thermal energy. This exchange, known as heat conduction, causes the warmer object to cool and the cooler object to warm.**

The thermal energy of an object is a measure of the speed of the object's particles. When two objects of different temperatures are put in contact with

one another, the faster moving particles collide with the slower moving particles, and energy is exchanged. The faster moving particles give up some energy and therefore slow down and the slower moving particles gain some energy and therefore speed up. This process, known as heat conduction, continues until an equilibrium is reached, where all the particles of both objects are moving at roughly the same speed. This equilibrium speed (or equilibrium temperature) must be somewhere in between the two objects' original temperatures. Therefore, the warmer object cools and the cooler object warms.

More Specifically:

- **The thermal current is directly proportional to the coefficient of thermal conductivity. Different materials have different coefficients of thermal conductivity.**

When heat is applied to a portion of a material, that heat will move through the material. This movement of heat through a material is called the thermal current. Depending on the composition of the atoms of that material, the heat may move very slowly, or it may move very quickly. This dependance is quantified by the coefficient of thermal conductivity. Each material has a unique coefficient of thermal conductivity. A high coefficient means heat moves very quickly; a low coefficient means heat moves very slowly. Below is a chart of thermal conductivities for some common materials. Compare your own empirical knowledge of how quickly heat moves through these materials with the values in the chart.

Material	Coefficient of Thermal Conductivity (W/mK)
Air	0.026
Water	0.609
Glass	0.8
Concrete	1.0
Steel	46
Copper	401

Values taken from Tipler, Paul A. Physics, Third Edition. 1991.

- ***When two objects of different temperatures are put in contact with one another, there is an exchange of thermal energy. This exchange, known as heat conduction, causes the warmer object to cool and the cooler object to warm.***

The thermal energy of an object is a measure of the speed of the object's particles. When two objects of different temperatures are put in contact with one another, the faster moving particles collide with the slower moving particles, and energy is exchanged. The faster moving particles give up some energy and therefore slow down and the slower moving particles gain some energy and therefore speed up. This process, known as heat

conduction, continues until an equilibrium is reached, where all the particles of both objects are moving at roughly the same speed. This equilibrium speed (or equilibrium temperature) must be somewhere in between the two objects' original temperatures. Therefore, the warmer object cools and the cooler object warms.

Related Demostrations:

The following demonstrations illustrate this physics topic:

- Collapsing Drum
- Liquid Nitrogen
- Shuttle Tile

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Article

Stainless Steel - Grade 310

Chemical Formula

Fe, <0.25% C, 24-26% Cr, 19-22% Ni, <2% Mn, <1.5% Si, <0.45% P, <0.3% S

Topics Covered

Background

Grade 310, combining excellent high temperature properties with good ductility and weldability, is designed for high temperature service. It resists oxidation in continuous service at temperatures up to 1150°C provided reducing sulphur gases are not present. It is also used for intermittent serv at temperatures up to 1040°C.

Grade 310S (UNS S31008) is used when the application environment involv moist corrodents in a temperature range lower than that which is normally considered "high temperature" service. The lower carbon content of 310S does reduce its high temperature strength compared to 310.

Like other austenitic grades these have excellent toughness, even down to cryogenic temperatures, although other grades are normally used in this environment.

Grade 310L (and proprietary versions of this grade), is a 0.03% maximum carbon version of 310, sometimes used for very specific corrosive environments, such as urea production.

Key Properties

These properties are specified for flat rolled product (plate, sheet and coil) i ASTM A240/A240M. Similar but not necessarily identical properties are specified for other products such as pipe and bar in their respective specifications.

Composition

Typical compositional ranges for grade 310 stainless steels are given in tabl 1.

Table 1. Composition ranges for 310 grade stainless steel

Grade		C	Mn	Si	P	S	Cr	Mo	Ni
310	min.	-	-	-	-	-	24.0	-	19.0
	max.	0.25	2.00	1.50	0.045	0.030	26.0		22.0
310S	min.	-	-	-	-	-	24.0	-	19.0
	max.	0.08	2.00	1.50	0.045	0.030	26.0		22.0

Mechanical Properties

Typical mechanical properties for grade 310 stainless steels are given in tat 2.

Table 2. Mechanical properties of 310 grade stainless steel

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brinell (HB) max
310	515	205	40	95	217
310S	515	205	40	95	217

Physical Properties

Typical physical properties for annealed grade 310 stainless steels are giver in table 3.

Table 3. Physical properties of 310 grade stainless steel in the annealed condition

Grade	Density (kg/m^3)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion (μm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Electric Resistiv (nΩ.m
			0-100° C	0-315°C	0-538° C	at 100°C	at 500°C		
310/S	7750	200	15.9	16.2	17.0	14.2	18.7	500	720

Grade Specification Comparison

Approximate grade comparisons for 310 stainless steels are given in table 4

Table 4. Grade specifications for 310 grade stainless steel

Grade	UNS No	Old British		Euronorm		Swedish SS	Japane JIS
		BS	En	No	Name		
310	S31000	310S24	-	1.4840	X15CrNi25-20	-	SUH 3:
310S	S31008	310S16	-	1.4845	X8CrNi25-21	2361	SUS 31

These comparisons are approximate only. The list is intended as a comparison of functionally similar materials **not** as a schedule of contractual equivalents. If exact equivalents are neede original specifications must be consulted.

Possible Alternative Grades

Possible alternative grades to grade 310 stainless steels are given in table 5

Table 5. Possible alternative grades to 310 grade stainless steel

Grade	Why it might be chosen instead of 310

3CR12	Heat resistance is needed, but only to about 600°C.
304H	Heat resistance is needed, but only to about 800°C.
321	Heat resistance is needed, but only to about 900°C. Subsequent aqueous corrosion resistance also required.
253MA (2111HTR)	A slightly higher temperature resistance is needed than can be provided by 310 Better resistance to reducing sulphide atmosphere needed. Higher immunity from sigma phase embrittlement is required.

Corrosion Resistance

The high chromium content - intended to increase high temperature properties - also gives these grades good aqueous corrosion resistance. The PRE is approximately 25, and seawater resistance about 22°C, similar to th of Grade 316. Excellent resistance at normal temperatures, and when in hig temperature service exhibits good resistance to oxidising and carburising atmospheres. Resists fuming nitric acid at room temperature and fused nitrates up to 425°C.

Subject to stress corrosion cracking but more resistant than Grades 304 or 316.

Heat Resistance

Good resistance to oxidation in intermittent service in air at temperatures u to 1040°C and 1150°C in continuous service. Good resistance to thermal fatigue and cyclic heating. Widely used where sulphur dioxide gas is encountered at elevated temperatures. Continuous use in 425-860°C range not recommended due to carbide precipitation, if subsequent aqueous corrosion resistance is needed, but often performs well in temperatures fluctuating above and below this range.

Grade 310 is generally used at temperatures starting from about 800 or 90 C - above the temperatures at which 304H and 321 are effective.

Heat Treatment

Solution Treatment (Annealing) - heat to 1040-1150°C and cool rapidly for maximum corrosion resistance. This treatment is also recommended to restore ductility after each 1000 hours of service above 650°C, due to long term precipitation of brittle sigma phase.

These grades cannot be hardened by thermal treatment.

Welding

Good characteristics suited to all standard methods. Grade 310S electrodes generally recommended for fusion welding. AS 1554.6 pre-qualifies welding 310 with Grade 310 rods or electrodes.

"Dual Certification"

310 and 310S are sometimes stocked in "Dual Certified" form - mainly in plate and pipe. These items have chemical and mechanical properties complying with both 310 and 310S specifications.

Applications

Typical applications include:

- Furnace parts
- Oil burner parts
- Carburising boxes

- Heat Treatment baskets and jigs
- Heat Exchangers
- Welding filler wire and electrodes

Source: Atlas Steels Australia

For more information on this source please visit Atlas Steels Australia